that it is more like the sperm-packing dragonflies. The reproductive biology of this species clearly warrants further study.

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REFERENCES

BAILEY, W.J. & RICHARDS, K.T. 1975. A report on the insect fauna of the Prince Regent River Reserve, north-west Kimberley, Western Australia. *Wildlife Research Bulletin of Western Australia* 3, 101-112.

THOMPSON, D.J. 1988. Dragons and damsels: an in-depth penetration of their sexual strategies. *Australian Natural History* 22, 506-510.

THOMPSON, D.J. 1989. A species of *Gynacantha* that breeds in caves (Anisoptera: Aeshnidae). *Notulae Odonatologicae* 3, 41-43.

WATSON, J.A.L. 1974. The distributions of the Australian dragonflies (Odonata). *Journal of the Australian Entomological Society* 13, 137-149.

WATSON, J.A.L. 1977. The distributions of the Australian dragonflies (Odonata): first supplement. *Journal of the Australian Entomological Society* 16, 277-279.

WATSON, J.A.L. 1991. The Australian Gomphidae (Odonata). *Invertebrate Taxonomy* (in press).

WATSON, J.A.L. & THEISCHINGER, G. 1984. The Australian Protoneurinae (Odonata). *Australian Journal of Zoology*, Supplementary Series 98, 1-51.

WATSON, T., THEISCHINGER, G. & ABBEY, H. 1991. *The Australian Dragonflies. A guide to the identification, distributions and habitats of Australian Odonata.* (CSIRO: Melbourne). (In press).

A SURVEY OF THE TERRESTRIAL VERTEBRATE FAUNA OF MOUNT WALTON, WESTERN GOLDFIELDS, WESTERN AUSTRALIA

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INTRODUCTION

Between 26 November and 3 December, and 10-11 December 1988, terrestrial vertebrates were surveyed in an area north-east of Mt. Walton in

the Western Australian goldfields. This area is of particular interest for two reasons. Firstly, it is the preferred site for the Integrated Hazardous Waste Disposal Facility to be owned and operated by the Health Department of Western Australia. Secondly, the area has not been previously surveyed, and is apparently little disturbed by human influence.

THE STUDY AREA

The survey area (30° 23' S, 120° 09' E) is located on vacant crown land 18.5km NNE of Mt. Walton and about 50km due north of the Perth-Kalgoorlie rail line (Figure 1). The area is on a slightly raised plateau 500m above sea level, and is situated in a region of flat to gently undulating plain. Geologically, this region is part of the Yilgarn block, with granitic rocks and intervening greenstone belts, that contain a variety of volcanic and metamorphic sedimentary rocks. Surface soils at the survey area are yellow sand or sand and gravel with sand predominating on the western section (Figure 1).

The climate is typical of the southern semi-arid zone, with mean maximum temperatures in January of 34°-36°C and minima in July of 4-5°C. Rainfall averages 259mm a year (mean for the three nearest weather stations at Kalgoorlie, Menzies and Southern Cross; Bureau of Meteorology 1988).

The vegetation of the region and of the survey area has been characterized by Beard (1972) as the Jaurdi system. *Acacia resinomarginea* is the dominant plant species on the survey area, and provides a relatively continuous shrub cover. Tall trees are mostly absent, but low mallee-form eucalyptus (*E. leptopoda and E. oldfieldii*) occur sparsely on sandy soils or in occasional stands. Occasional *Choretrum glomeratum* and *Callitris preissii* occur as small shrubs on gravel soils. Other plant genera characteristic of sand plains in this part of the goldfields are conspicuously absent or very sparse at the survey area (e.g. *Melaleuca, Plechtrachne, Lepidobolus, Hakea, Grevillea, Baeckea, Phebalium*) (Newbey & Hnatiuk 1985). The vegetation is structurally homogeneous, probably as a result of fires that swept the survey area in 1979. In early 1988, three parallel east-west tracks were bulldozed at 1km intervals across an access track that allows entry to the area. The northern-and southern-most of these latter tracks extend for 1km either side of the access track; the central one extends 2km either side (Figure 1).

SURVEY METHODS

Between 10 and 20 PVC pitfall traps (15cm wide, 50cm deep) were set up 5m apart in lines at 15 points over the survey area (Figure 1). Flywire drift fences were established along eight of the lines (Friend *et al.* 1989). Pits were baited by smearing mutton fat around pit rims as well as on the adjacent drift fence.

Two types of metal traps were also used. Elliott folding metal traps (33 x 10 x 10cm) were set in three lines, each comprising 33-34 traps, on the western half of the survey area. These were placed 10-15m apart under shrubs or other cover, and were baited with a mixture of rolled oats, peanut butter and honey. Tomahawk wire cage traps (45 x 15 x 16cm) were set in two lines, each comprising 15 traps, on the eastern and western sides of the main access track. These were placed 10-15m apart under shrubs, and baited with bread and peanut butter. Trapping effort during the survey totalled 360 trap nights (520 trap days) for the metal traps and 900 trap nights (1060) for the pitfall traps.

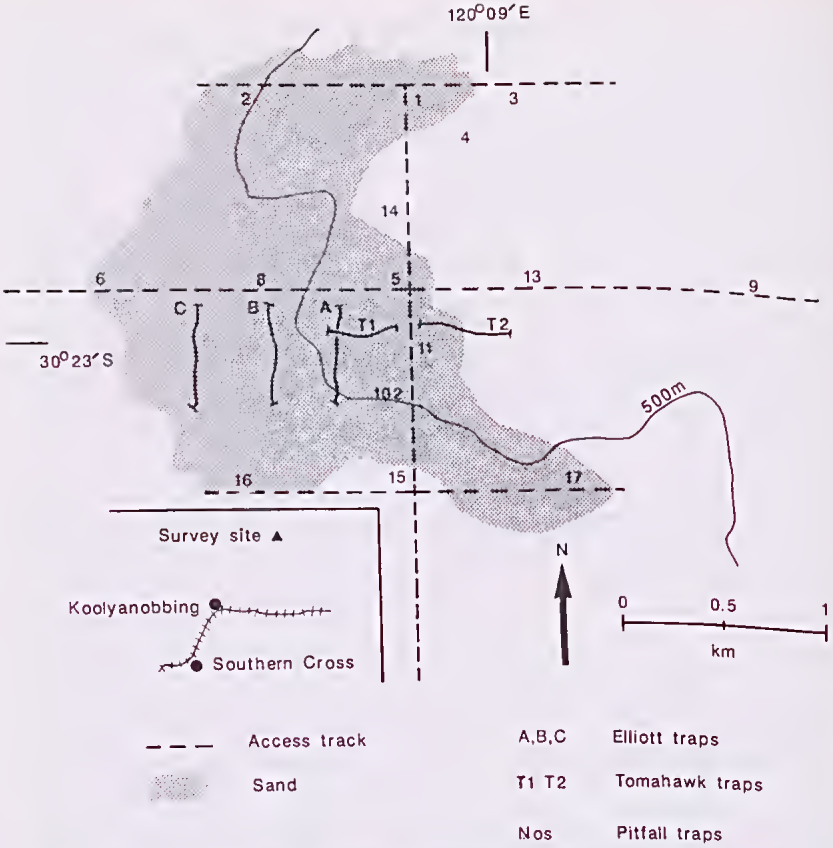

Fig. 1. The survey area, showing trapping points, access tracks and surface geology. Inset shows the regional location.

Spotlighting for geckos was carried out in all parts of the survey area using headlamps with dull white light. Raking was also carried out to detect small burrowing reptiles.

Hand searching involved removal of bark flakes from trees, digging out of burrows, and examination of logs and piles of debris. Spotlighting and searching occupied approximately 40 hours during the survey. Predator droppings were collected opportunistically and analysed for vertebrate remains. Reptilian remains were identified by reference to specimens collected at Bungalbin Hill, 45km WNW of the survey area, mammalian remains by reference to the structure of the hair (Brunner & Coman 1974). Other signs, such as echidna diggings and droppings, were also recorded.

Nomenclature of mammals follows Strahan (1983) and Kitchener *et al.* (1984). Nomenclature of reptiles follows Storr *et al.* (1981, 1983, 1986, 1990).

RESULTS

Seven species of mammals, twenty-two species of reptiles and one frog were recorded (Table 1). The Little Long-tailed Dunnart *Sminthopsis dolichura*

was the most abundant species of mammal and occurred throughout the survey area (Table 1). The Knob-tailed Gecko *Nephurus stellatus* was the most abundant reptile, with 19 males and seven females captured a total of 28 times. This species was captured on all pitfall trap lines except 4 and 9, where the gravelly soil may have precluded construction of burrows. Except for *Ctenotus schomburgkii* (13 observations), all other species were represented by less than 10 records (Table 1). All species occurred on the survey area except the Echidna *Tachyglossus aculeatus*, Feral Cat *Felis catus* and goanna *Varanus tristis*, which were observed within 5km of the survey area, and a Gwardar *Pseudonaja nuchalis* which was observed on a track at Mt. Walton.

Table 1: Terrestrial vertebrate fauna of Mt. Walton.

Numbers represent minimum numbers of individuals or signs.

	Trapped	Observed	Signs
MAMMALS			
Tachyglossus aculeatus		1	1
Macropus fuliginosus		3	1
Sminthopsis dolichura	17		
Sminthopsis hirtipes	1		
Pseudomys albocinereus	9		
Mus domesticus	2		
Felis catus		1	
REPTILES			
*Nephurus stellatus**	26		3
Diplodactylus assimilis	1		
*Diplodactylus granariensis**	1	1	
Diplodactylus maini	1	1	
*Ctenophorus fordi**	2	7	
Ctenophorus reticulatus		2	
Ctenophorus cristatus		1	
Ctenophorus scutulatus	1	2	
Moloch horridus	1		2
Pogona minor	1	1	
Varanus gouldii	2		6
Varanus tristis		1	
Ctenotus schomburgkii	11	2	
*Egernia inornata**	3		6
Morethia obscura	1		
Menetia greyii	2	1	
Lerista macropisthopus	1		
Tiliqua occipitalis	1	1	
Delma (?) australis			1
Lialis burtonis			1
Ramphotyphlops australis		1	
Pseudonaja nuchalis		1	
FROGS			
Neobatrachus sp.*			1

* Voucher specimens donated to W.A. Museum.

Specific identification of the *Neobatrachus* was not possible, as the single specimen was found crushed on a track. There is also slight doubt about the specific identity of the *Delma*, which was recovered from a goanna dropping. However, *D. australis* is likely to be correct, as the distinctive blunt nose of this species was intact in the dropping.

DISCUSSION

The survey indicates that the terrestrial vertebrate fauna of the Mt. Walton area is relatively diverse. The 28 species of native vertebrates recorded

(*Felis catus* and house mice *Mus domesticus* are introduced) are widespread in other parts of the state or elsewhere in Australia, and to a large extent are typical of the southern and central sandplain faunas.

To place the results of the present survey into a regional perspective, it is of interest to compare the fauna of the survey area with that from other, adjacent sandplain areas. Two sites are available for such a comparison: 1) Bungalbin Hill, 45km WNW of the survey area, and 2) Mt. Jackson, 88km to the west (Dell & How 1985).

Comparisons of the native faunal diversity are given in Table 2, and show that:

1. All species present at the survey area have been recorded at Bungalbin Hill; many have also been recorded at Mt. Jackson;
2. Overall faunal diversity at Bungalbin Hill is 71% higher than that at the survey area, and 36% lower at Mt. Jackson than at the survey area; and
3. Rodents, marsupials, geckos and skinks are relatively poorly represented in the survey area, in comparison with Bungalbin Hill, whereas marsupials, dragons and skinks are well represented in comparison with Mt. Jackson. Rare or unusual species such as Yvonne's Ningaui (*Ningaui yvonneae*) and *Ctenotus xenopleura* occur in the Bungalbin Hill — Mt. Jackson area, but not in our survey area.

Table 2: Comparison of native species of mammals, reptiles and frogs recorded from sandplain at three sites in the western goldfields of W.A. Data from Dell & How (1985), present study, and C.R. Dickman, unpublished.

	No. species recorded at:			% of Mt. Walton species recorded at:	
	Mt. Walton	Bungalbin Hill	Mt. Jackson	Bungalbin Hill	Mt. Jackson
MAMMALS					
Monotremata	1	1	1	100	100
Marsupialia	3	7	1	100	33
Rodentia	1	4	2	100	100
REPTILES					
Gekkonidae	4	9	6	100	50
Agamidae	6	7	3	100	50
Varanidae	2	2	1	100	50
Scincidae	6	10	2	100	17
Pygopodidae	2	4	1	100	0
Typhlopidae	1	1	0	100	0
Elapidae	1*	2*	0	100	0
FROGS	1	1	1	100	0

* Marginal record

Differences in the numbers of species recorded may partly reflect differences in sampling effort and time of survey. For example, while total trapping effort at Mt. Walton was similar to that at Bungalbin Hill, three sandplain sites were surveyed at the latter area three times over an extended period between September 1979 and November/December 1981 (Dell & How 1985). At Mt. Jackson, one sandplain site was also surveyed three times, but with one third of the trapping effort expended at Mt. Walton.

Two further factors probably affected the results of the present survey. Firstly, rain fell heavily on three nights of the survey period, and became torrential on the morning of 3 December. On the one hand, rain probably reduced the activity of nocturnal geckos and of crespuscular small mammals and skinks, and thus probably decreased overall trap success. On the other hand, rain undoubtedly caused the emergence and subsequent detection of the frog *Neobatrachus* sp., and also facilitated detection of the cryptic, burrowing blind snake, *Ramphotyphlops australis*. The blind snake was observed foraging on swarming termites on leaf litter, and was probably driven to the surface by waterlogging or was attracted by the abundant prey. Although the overall effect of rain is difficult to assess, it fell only in the latter part of the survey and is probably unlikely to have had a significant effect on the survey results.

The second and probably major factor that ultimately affected vertebrate diversity is an intense fire that swept the survey area in 1979. This event could have reduced species diversity in three ways.

1. The fire probably killed most of the spinifex present, since only three regenerating hummocks of *Plechtrachne* sp. were found throughout the survey. Intense fires kill both foliage and a percentage of the buried meristems of spinifex (Jacobs 1984). Comparisons of the species lists for Bungalbin Hill and the survey area indicate that the species missing from the survey area are mostly "spinifex specialists." These species include *Ningaui yvonneae*, *N. ridei* (marsupials), *Ctenotus pantherinus*, *C. atlas*, *C. xenopleura*, *Omolepida branchialis* (skinks), *Delma nasuta*, *D. butleri* (legless lizards), *Diplodactylus elderi*, *D. stenodactylus* (geckos) and others (Pianka 1986, Wilson & Knowles 1988). Casual observations in spinifex heathland 8-10km south of the survey site on 28 November 1988 revealed the presence of *C. pantherinus*, *C. atlas* and *O. branchialis*; it is highly likely that other spinifex species would have been recorded had the area been surveyed systematically. The importance of spinifex in promoting reptilian diversity in arid Australia has been emphasized recently by Morton & James (1988).
2. The fire probably stimulated the proliferation of *Acacias* at the expense of other flowering shrubs, thus precluding use of the site by nectar-feeding species such as the pygmy-possum, *Cercartetus concinnus*. Although birds are not included formally in this report, avian diversity was unusually low at the survey site, with only emus, nankeen kestrels, Australian ravens and thornbills (*Acanthiza apicalis*, *A. uropygialis* and *A. chrysorrhoa*) being noted in any numbers. Nectar-feeding birds were virtually absent, as would be expected given the lack of their food resource.
3. The vegetation structure at the survey site is remarkably homogeneous, and probably the result of post-fire regeneration. Such homogeneity would reduce the variety of habitat niches available to terrestrial vertebrates, and hence further reduce their diversity.

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REFERENCES

BEARD, J.S. 1972. The vegetation of the Kalgoorlie area, Western Australia. *Vegetation survey of Western Australia.* Vegmap Publications, Sydney.

BRUNNER, H. & COMAN, B.J. 1974. *The identification of mammalian hair.* Inkata Press, Melbourne.

BUREAU OF METEOROLOGY. 1988. *Climatic averages Australia.* Australian Government Publishing Service, Canberra.

DELL, J. & HOW, R.A. 1985. Vertebrate fauna. *In:* The biological survey of the Eastern Goldfields of Western Australia. Part 3, Jackson-Kalgoorlie study area, pp. 39-66. *Rec. West. Aust. Mus.*, Suppl. 23.

FRIEND, G.R., SMITH, G.T., MITCHELL, D.S. & DICKMAN, C.R. 1989. Influence of pitfall and drift fence design on capture rates of small vertebrates in semi-arid habitats of Western Australia. *Aust. Wildl. Res.* 16: 1-10.

JACOBS, S.W.L. 1984. Spinifex. *In: Arid Australia* (Eds. H.G. Cogger, & E.E. Cameron), pp. 131-142. Australian Museum, Sydney.

KITCHENER, D.J. STODDART, J. & HENRY, J. 1984. A taxonomic revision of the *Sminthopsis murina* complex (Marsupialia, Dasyuridae) in Australia, including descriptions of four new species. *Rec. West. Aust. Mus.* 11: 201-247.

MORTON, S.R. & JAMES, C.D. 1988. The diversity and abundance of lizards in arid Australia: a new hypothesis. *Am. Nat.* 132: 237-256.

NEWBEY, K.R. & HNATIUK, R.J. 1985. Vegetation and flora. *In:* The biological survey of the Eastern Goldfields of Western Australia. Part 3, Jackson-Kalgoorlie study area, pp. 11-38. *Rec. West. Aust. Mus.*, Suppl. 23.

PIANKA, E.R. 1986. *Ecology and natural history of desert lizards.* Princeton University Press, New Jersey.

STORR, G.M., SMITH, L.A. & JOHNSTONE, R.E. 1981. *Lizards of Western Australia I. Skinks.* University of W.A. Press, Perth.

STORR, G.M., SMITH, L.A. & JOHNSTONE, R.E. 1983. *Lizards of Western Australia II. Dragons and monitors.* Western Australian Museum, Perth.

STORR, G.M., SMITH, L.A. & JOHNSTONE, R.E. 1986. *Snakes of Western Australia.* Western Australian Museum, Perth.

STORR, G.M., SMITH, L.A. & JOHNSTONE, R.E. 1990. *Lizards of Western Australia III. Geckos and pygopods.* Western Australian Museum, Perth.

STRAHAN, R. (ed.) 1983. *Complete book of Australian mammals.* Angus and Robertson, Sydney.

WILSON, S.K. & KNOWLES, D.G. 1988. *Australia's Reptiles.* Collins, Sydney.